Overview of the U.S. Fishing Industry

Introduction

NOAA's vision for increasing the Nation's wealth includes maintaining fishery resources over time to provide Americans with both commercial and recreational fishing opportunities and a safe supply of high quality seafood. This vision incorporates both biological and economic sustainability: stock levels maintained at biologically healthy levels; optimal harvest of fish over time, using the least-cost levels of capital, labor, and other resources; and equitable allocation of the harvest between user groups. Information is presented in this overview chapter to help characterize the economic health of U.S. fishery resources at the national level. This chapter describes and interprets some of the major recent trends in the U.S. harvesting, processing, trade, retail, and recreational sectors, and highlights relevant economic issues affecting each sector. It also identifies data needs in each sector that have to be met to enable economic analysis that would be useful in the management process.

At the national level, many U.S. fisheries are characterized by an increasing number of allocation disputes, including those between commercial and recreational fishermen, between various subsets of the commercial harvesting sector, and between the harvest sector and environmental interests. The solutions intended to ensure the biological health of fishery resources while resolving allocation issues typically include imposition of increasingly strict and more complex regulations. As discussed in Chapter 1, these solutions are usually ineffective from the standpoint of economic sustainability of fishery resources or the economic health of the fishing and seafood-related industries. Thus, when possible, this chapter identifies alternative solutions for management that could simultaneously achieve both types of sustainability envisaged by NOAA.

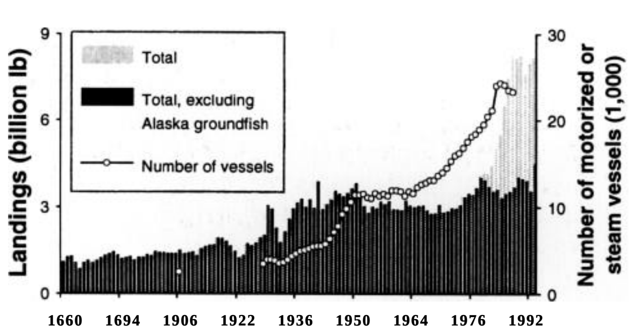


Figure 2-l
U.S. commercial domestic landings of food fish.

The U.S. Commercial HarVesting Sector

Quantity, Ex-vessel Value and Composition of U.S. Landings

The total domestic commercial landings of edible fmfish and shellfish since 1880 are shown in Figure 2-1. Once Alaska groundfish landings are subtracted, total U.S. landings have remained fairly stable since World War II. In the past decade, domestic landings of all commercial fishery products have increased fairly steadily, reaching a record high of 10.5 billion pounds in 1993 (Fig. 2-2). Total real revenues from U.S. fishery products reached their peak in 1988. The increase in volume without an equivalent increase in real revenues is due to the fact that increasingly more lower-valued species are being harvested. However, without information on the cost of harvest or consumer surplus, ex-vessel value of landings only yields a measure of the gross revenues of U.S. fishermen, not profits or net economic benefits. Additionally, landings figures only measure how much has been harvested, not how efficiently that harvest was achieved.

Relative to the rest of the fishing nations, the United States was the world's fifth largest ducer of seafood (by weight) in 1993 (USDOC, 1994), harvesting almost 6% of the world catch, behind China (17%), Peru (8%), Japan (8%), and Chile (6%). Within the United States, the Pacific region's share of total harvest has been increasing over the past 11 years, while its share of total revenues has increased only slightly (Fig. 2-3 and 2-4). This is primarily due to the large harvests of Alaska groundfish, the most important U.S. species group in terms of volume in 1993 but ranked fourth in terms of total gross revenues.

Between 1984 and 1993, total U.S. domestic finfish landings have been significantly greater than shellfish landings, accounting for between 80 and 90% of total volume, while contributing only 48-58% of the total ex-vessel value (Fig. 2-5). Again, the steady increase in finfish landings over time, as well as the downward trend in finfish revenues since 1988 are attributable to the remarkable development of the low unit value Alaska groundfish fishery, as well as concurrent decreases in the harvest of other high-valued finfish.

The ex-vessel revenues and quantity of landings of the ten most valuable U.S. commercial species groups in 1993 are shown in Figure 2-6. Crabs, shrimp, and salmon are the three highest-valued species groups. When ranked against individual species (rather than species groups), walleye, or Alaska pollock, is also first in terms of total revenues. In 1984, pollock was not ranked within even the top fifteen species in terms of volume or value. Of the remaining six species, three are shellfish, which are characterized by high unit values and relatively low landings.

Over time, the progression toward harvest of more lower-valued species is to be expected. In the development of any fishing industry, fishermen will first target those species that will earn the most profits, and eventually transfer effort to increasingly lower-valued species as the higher-valued stocks become harder to catch. Even the best-managed fisheries sector would be characterized by a harvest mix of high- and low-valued fish. A problem only arises when the mix tends too rapidly towards the harvest of lower-valued stocks because of the successive depletion of higher-valued stocks. A fishing sector that harvested all of its fisheries at sustainable levels would yield greater net economic benefits than one that developed, exploited, and ultimately overfished each of its fisheries in turn. Under conditions of open access, the rate of exploitation of all stocks is generally higher than under controlled access fishing, and there is a greater tendency for stocks to exceed the points of economic and biological sustainability.

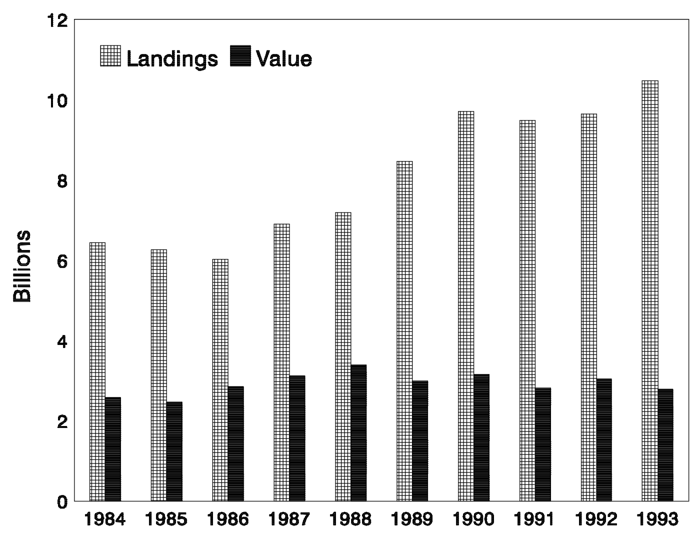


Figure 2-2
Landings and real ex-vessel value of all U.S. commercial fisheries.

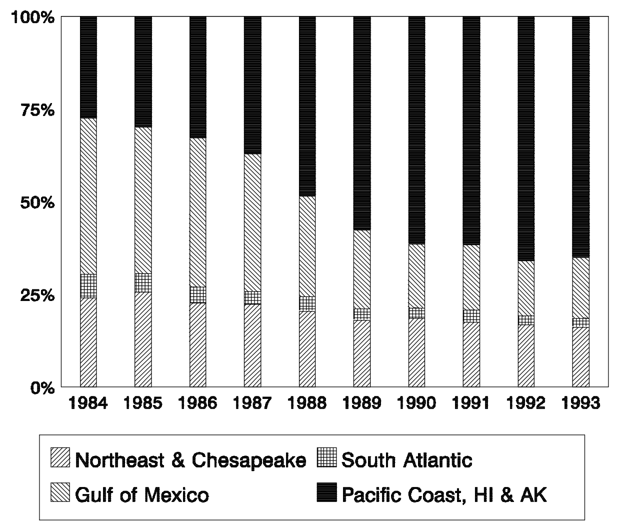


Figure 2-3
Percent of U.S. domestic landings by region.

Effort in U.S. Fisheries

Defining and estimating efficient or cost-effective levels of effort is important for understanding the losses to society from the misallocation of resources such as labor and capital (or the benefits to be gained from proper allocation). Detailed economic analyses of the majority of U.S. fisheries on an individual basis would probably reveal that the amount of effort used is greater than that necessary to harvest the maximum economic yield. That is, most U.S. fisheries can probably be characterized as overcapitalized, with too many vessels, too much gear, and too much time spent at sea harvesting fish at a higher than optimal cost per unit of effort, hurting both consumers and producers.

Evidence exists of the magnitude of economic benefits lost as a result of open access. For example:

- The economic benefits in the New England groundfish fishery could be increased by $150 million annually. To realize these benefits, however, effort would need to be reduced by 70% (Edwards and Murawski, 1993).
- The number of full-time vessels in the Gulf of Mexico shrimp fishery more than doubled between 1966 and 1991 (Fig. 2-7), but annual net revenues per vessel decreased about 75% to approximately $25,000 (in 1990 dollars). Total landings by full-time vessels were virtually unchanged over the time period, with an annual average of about 200 million pounds during 1966-75 and a 250-million-pound average between 1981 and 1991. With a fleet of over 16,000 vessels and boats operating in 1988, it was estimated that one-third of the fleet could harvest the same amount of shrimp; that is, two-thirds of the fleet could be retired, with the capital investment shifted to other sectors of the economy (Ward and Sutinen, 1994).
- Total landings in the Pacific halibut fishery and the length of the open season from 1924 to the present are shown in Figure 2-8. Landings rose rapidly during 1975-93, with a high in 1988, while the length of the season decreased steadily to only a handful of days.
- A study of the Bering Sea pollock fishery estimates that “the catching capacity of vessels ... appears to be double or more the annual quota” and observes that given current market conditions, “...considerable downsizing would be needed to restore profitability in this [Bering Sea/Aleutian Islands pollock fisheries] fleet” (Miller et al.[1]).

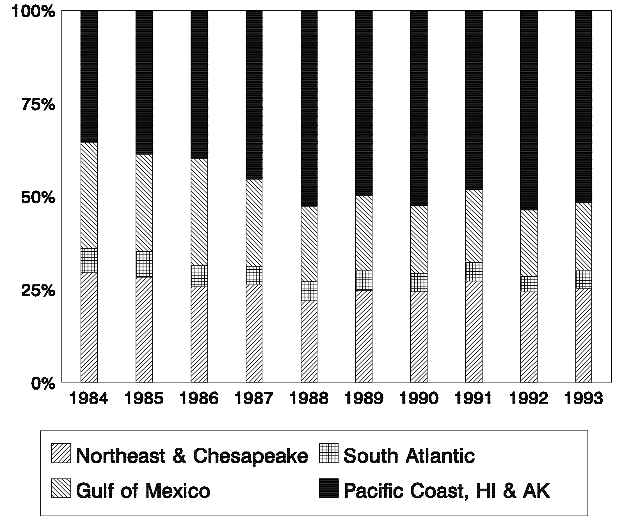


Figure 2-4
Percent of value of U.S. domestic landings by region.

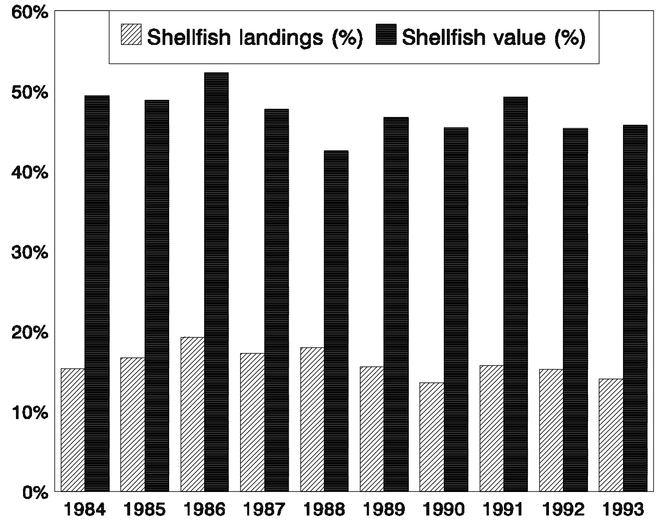


Figure 2-5
Shellfish value and volume as a percentage of total domestic revenues and landings.

[1]Miller, M., D. Lipton, and P. Hooker. 1994. Profile of change: A review of offshore factory trawler operations in the Bering Sea/Aleutian Islands pollock fishery. Report to the National Marine Fisheries Service, 37 p.

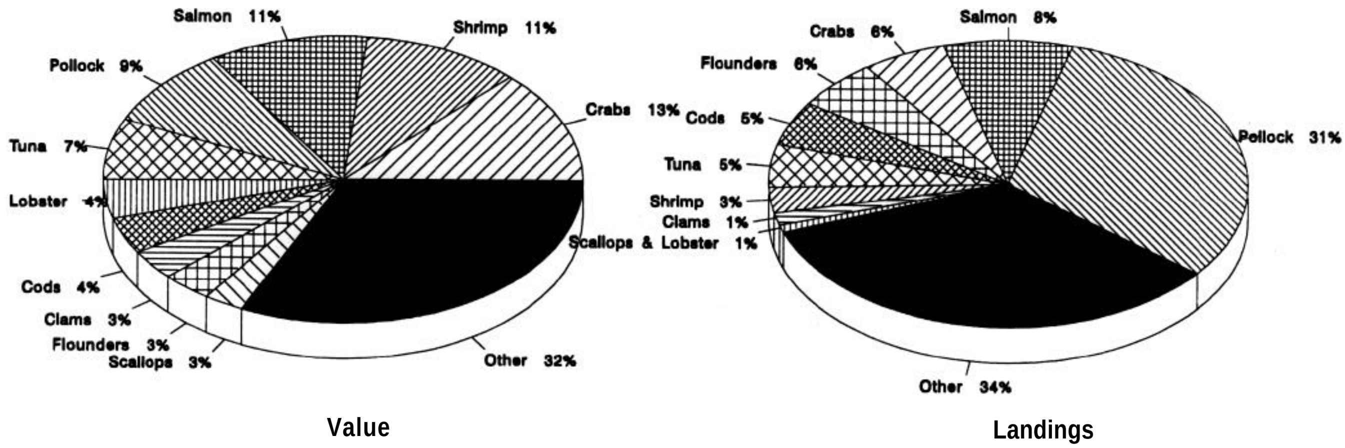


Figure 2-6
Ten highest valued species groups landed by U.S. fishermen in 1993.

- In **the New** England otter trawl fishery, premium prices are paid for larger haddock, harvest of small, 2-3 year old haddock yields a relatively lower-valued product. Open-access fishing usually results in the harvest of younger, smaller-sired fish. In addition to reducing the reproductive stock by not allowing fish to mature, value is often lost by not delaying harvest until fish have attained a more marketable size. That is, the opportunity cost of leaving fish in the ocean to grow and reproduce is foregone.
- On Georges Rank off New England, the relative abundance of traditionally high-valued cod, haddock, and yellowtail flounder decreased from almost 50% to 14% between 1963 and 1993, while the relative abundance of less commercially valuable skates, spiny dogfish sharks and other elasmobranchs increased from about 40% to more than 75% (Fig. 2-9). Unlimited access to these historically valuable fishing grounds has greatly affected the balance of the ecosystem and, ultimately, the composition of the landings.
- In the Atlantic surf clam fishery, which implemented an ITQ system in 1990, the fleet was reduced by 54% within 2 years; landings per vessel increased while total landings increased slightly. The value of the surf clam resource was estimated to be $57 million in 1992, with a resource rent of over $11 million accruing directly to the surf clam industry (the Northeast regional spotlight article provides a full discussion). Resource rent that was being dissipated before the assignment of use rights by the ITQ system is now being captured directly by the shareholders.

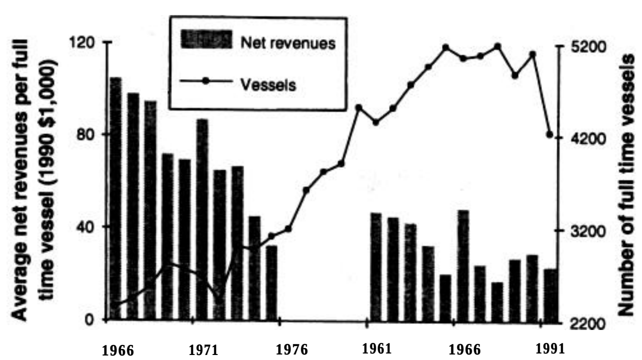


Figure 2-7
Overcapitalization of the profitable Gulf of Mexico U.S. shrimp fishery.

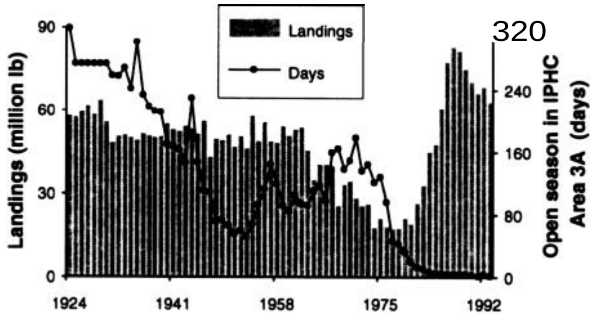


Figure2-8
Open season in the U.S. Pacific halibut fishery.

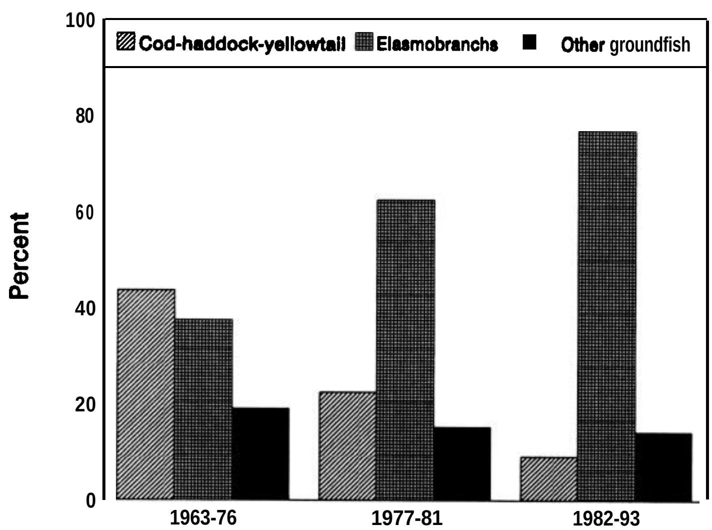


Figure 2-9
Relative abundance of demersal finfish resources on Georges Bank.

- Since implementation of an ITQ system in the Southeast wreckfish fishery in 1992, the number of vessels with wreckfish permits has decreased from 91 in 1991-92 (with 44 vessels reporting catch) to 21 in 1994-95 (with 11 reporting catch); wreckfish prices have increased, total landings are lower but more constant throughout the year, and the value per share is about $10,000, for a total value in the fishery of close to $1 million.

The examples above illustrate the type and magnitude of the losses associated with traditional open-access fisheries management. The gain in net economic benefits (NEB's) that could be achieved by solving the open-access problem and reducing effort in U.S. fisheries is fairly clear.

While fisheries economists and managers generally agree that many U.S. fisheries are overcapitalized, demonstrating this empirically on a systematic basis is difficult. The data necessary to measure or estimate the degree of overcapitalization and the subsequent rent dissipation are often not available or vary from fishery to fishery. For example, to measure economic rent requires: 1) detailed information on the number of vessels, 2) the number and types of gear used by each vessel, 3) the number of days at sea spent by individual vessel, and 4) the costs incurred by vessels. (Table 2-l provides a more complete list of the status of necessary data elements and analyses.) Funds are unavailable or insufficient to collect these data. Moreover, even where funds are available, there is a widespread reluctance from participants to provide these data. Where data were available, the regional chapters in this report document the losses in NEB's from excessive effort in their fisheries or gains in NEB's from programs that effectively reduced effort.

The U.S. Fishing Fleet

The U.S. fishing fleet is quite diverse in terms of sixes and gear types. Vessel sizes and types vary significantly between fisheries as well as between geographic areas. One consequence of the size and diversity of the harvest sector is that management of all U.S. fisheries with a single policy is not feasible. Even individual fleets are quite diverse, and each fishery has unique biological, economic, and sociological characteristics that make broad-based policy impractical. On the other hand, regulation on a fishery-by-fishery basis is not practical or effective. Vessels are extremely mobile and are often able to change gear types quite readily. In addition, retiring vessels from fishing altogether is often difficult; once a vessel is built and equipped for fishing, few alternative uses exist for it. This provides incentive for vessels to transfer effort from one fishery or geographic location to another, rather than leave fishing altogether, when regulations become binding. When vessels shift effort to open-access fisheries or to those regulated with traditional command-and-control methods, the new vessels may impose stock and/or crowding externalities on existing vessels. When controlled access systems are in place, these externalities are taken into account when fishermen decide whether or not to enter a new fishery. Fishermen would only shift effort to another fishery if it was worth the cost of purchasing the right to harvest in that fishery. Thus, management systems that take into account the potential transfer of effort, and provide the correct incentives and signals for entry and exit of vessels and fishermen, are important for ensuring that effort reductions in one fishery do not exacerbate conditions in other fisheries.

Disappointingly, the most recent complete data available at the national level on U.S. commercial fishing vessels are from 1987. In that year, there were about 23,000 vessels in operation, accounting for 3% of the world's fishing vessels, and totaling almost 1,000,000 gross registered tons (GRT). The Food and Agriculture Organization (FAO) of the United Nations estimates that the U.S. fleet was the world's fourth largest in 1987 in terms of total GRT (4%), following the former U.S.S.R., China, and Japan (FAO, 1991). Fishing vessels from these four countries comprised 70% of the vessels operated by 50 principal fishing nations and 60% of the total GRT.

Figure 2-10 demonstrates the dramatic rise in the number of commercial steam or motor vessels (5 net tons or larger) over the period 1880-1987 and, combined with the landings exhibited in Figure 2-1, suggests that increasingly more vessels are catching roughly the same amount of fish. Furthermore, technological advances over this time period have greatly increased the efficiency of these vessels.

Table 2-1
Data needs and economic information for harvesting sector.

Item	Data/estimates available: Routinely for all FMP's	Routinely for some FMP's	By special study	Not available
Ex-vessel landings, revenues and prices, by species, by vessel	✔			
Variable and fixed costs of production, by vessel			✔	
Bycatch volume and type, by fishery		✔		
Current number of vessels, by fishery and gear type		✔		
Optimal number of vessels, by fishery				✔
Physical characteristics of vessels (gross registered tons, age, etc.)		✔		
Economic/financial characteristics of vessels (cost of construction, purchase price, current market value, etc.)			✔	
Season length, by fishery	✔			
Number of days fished, by vessel		✔		
Number of full- and part-time fishermen, by fishery		✔		
Estimated landings and prices at optimal level of effort, by fishery			✔	
Economic values (i.e., producer surplus and profits) by fishery, at current and optimal effort levels			✔	
Market value of shares and number of shares, where controlled access systems are implemented			✔	
Socioeconomic characteristics of commercial fishermen			✔	
Costs of administration, monitoring and enforcement of regulation, by FMP				✔

Technological Development and Effort

Technological advances have played an important role in the development of U.S. fisheries, particularly in the harvesting sector, but also in the way seafood is processed, distributed, and marketed. The U.S. fleet evolved from mainly sailing vessels in the late 1800's, to steamers and schooners with auxiliary gasoline-powered engines in the early 1900's, and finally to an almost complete conversion to diesel-powered vessels by the 1930's. Concomitant increases in size and speed allowed vessels to fish in ever more distant waters. Sophisticated gear types were available early on: purse seiners were in use in Alaska by 1870, followed by longliners in 1885; otter trawl technology was introduced to groundfish and shrimp fisheries on all coasts during the early 1900's. Great Britain's F/V *Fairtry* launched the age of factory ships in 1954; scores were pulse-fishing herring, haddock, halibut, and salmon from traditional U.S. fishing grounds by the late 1960's.

Other significant inventions or advancements that helped the development of the harvest sector include: onboard refrigeration, the Puretic power block for seine retrieval, double trawls, durable nylon and synthetic fiber for nets and seines, sophisticated electronics for navigation and location of fishing grounds and fish, and seaplanes and helicopters to locate schools of fish.

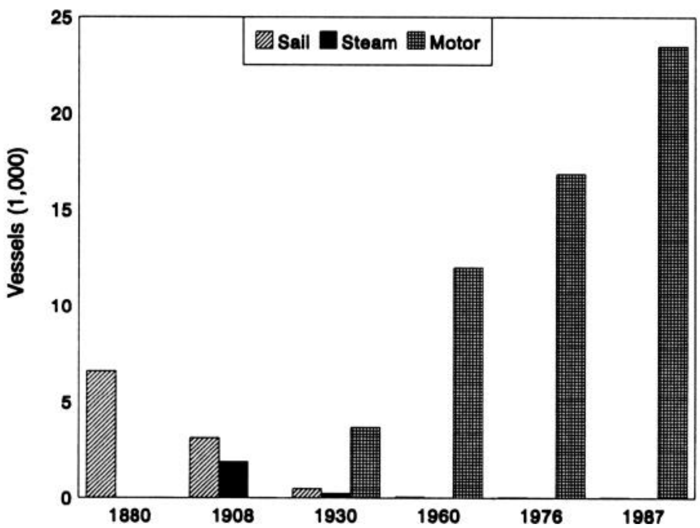
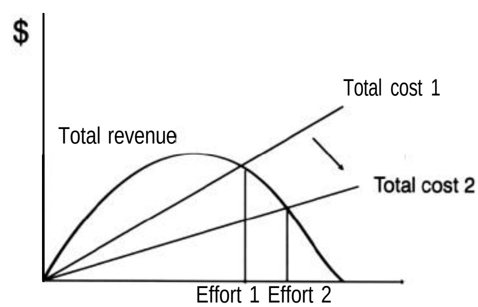


Figure 2-10
Number of U.S. commercial fishing vessels.



Technological improvement leads to lower unit costs, higher open-access fishing effort, zero rents, and lower catch.

Over time, these technological advances and innovations made it possible and affordable for fishermen to harvest more fish more effectively. With harvests essentially unfettered by management, technology developments accelerated the rate at which stocks could be depleted. Without incentives to leave fish stocks unharvested, the net economic benefits that should have arisen from the fishermen's use of technology (as a result of lcwer costs) were instead dissipated by the depletion of stocks made possible by the technology. While Figure 2- 10 demonstrates the evolution of the U.S. fishing fleet in terms of absolute numbers, it hardly reveals the enormous gains in fishing power afforded by technology and ingenuity during the 20th century. Despite tremendous changes in technology, total domestic commercial harvest (excluding Alaska groundfish) has increased only marginally since World War II (Fig. 2- 1).

Management of U.S. Fisheries

Concern for the sustainability of fish resources was evident as early as 187 1, when Congress wrote that "... the most valuable food fishes of the coast and the lakes of the U.S. are rapidly diminishing in number, to the public injury, and so as materially to affect the interests of trade an[d] commerce...." However, it was not until 1976, when the Magnuson Fishery Conservation and Management Act (MFCMA) was implemented, that the Federal government was awarded responsibility for actively managing fish resources and fisheries. The MFCMA expanded the Federal role in fisheries to include management of resources from 3 to 200 miles off the coast for most species and beyond 200 miles for anadromous species such as salmon[2] However, Congress has been equivocal about the importance of economic efficiency as a goal for fisheries management. For example, National Standard 5 states:

"Conservation and management measures shall, where practicable, promote efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose."

Prior to the MFCMA, the Federal government fisheries management role was mostly limited to fleet subsidization and research, and to negotiating trade policy and many international agreements and treaties on behalf of the fishing industry.[3] For example, a number of Federal programs actively encouraged the development of the fishing industry:

- The 1964 Amendment to the Fishing Fleet Improvement Act financed up to 50% of vessel construction costs.
- The 1969 Fishermen's Protection Act defrayed the costs of foreign seizure of U.S. vessels.
- The 1970 Fishing Vessel Construction Fund Program deferred payment of Federal in-

[2]Highly migratory species (tunas, sharks, and other billfishes) were included in a 1990 amendment to the Magnuson Act.

[3]Exceptions to this generalization include the Sponge Act of 1906 which prohibited sponge harvest in the Gulf of Mexico or Strait of Florida by divers during May-September and regulations in Alaska's salmon fisheries.

come taxes provided that the money was used to construct or reconstruct a vessel.

- The 1973 Fishing Fleet Vessel Obligation Guarantee Program financed up to 87.5% of the cost of construction, reconstruction, or reconditioning of fishing vessel and shoreside **facilities.**[4]

The Federal government has also sponsored much scientific, gear, and marketing research, supported by the Dingell-Johnson Act of 1950 and Wallop-Breaux Amendments, the Saltonstall-Kennedy Act of 1954, and the Commercial Fisheries Research and Development Act of 1964. Research conducted with these funds has primarily been aimed at promoting development of the fishing industry.

The United States is not the only country to encourage development of its domestic fisheries. The Food and Agricultural Organization estimates that the total value of the world's marine catch is approximately $70 billion per year while total variable costs are approximately $124 billion per year (FAO, 1993). Various subsidies to fishermen are hypothesized to make up the difference between revenues and costs. The need to subsidize fishermen to help them stay in business is one indication that fisheries are not economically sustainable.

In terms of fisheries management objectives since implementation of the MFCMA, achievement of maximum sustainable yield has been the principal goal. A patchwork of legislation and subsequent regulations, centered on complicated and sometimes conflicting gear restrictions, quotas, trip limits, and time and area closures, has been the result. These effort control management strategies have been largely ineffective, often encouraging inefficient and excessive use of effort and capital of existing vessels, and in some cases, promoting and subsidizing further entry of new vessels. As discussed in Chapter 1, these "command-and-control" measures may achieve short-run stock improvements, but in the long-run they generally are not successful at reducing effort. Despite early recognition of the potential for overfishing in the United States, the actions taken to control harvests from U.S. waters have often been ineffective from the standpoint of both biological and economic sustainability. Figure 2-11 shows the landings for six fisheries from 1837-1993. The profiles of these six are strikingly similar and are probably representative of the pattern of discovery, development, and exploitation in a number of fisheries.

[4]This act was **intended to make U.S.-built vessels as affordable as foreign-built vessels would be if not for a 1973 embargo.**

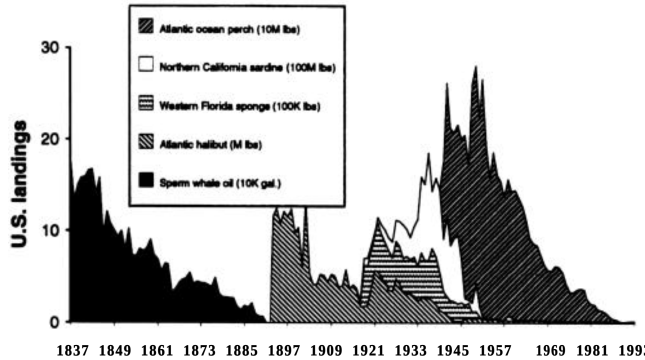


Figure 2-11
Fish resources are discovered, exploited, **and depleted in open-access fisheries.**

A majority of U.S. fisheries have been "diagnosed" by NMFS biologists as operating at or above long-term potential yield, or maximum sustainable yield: 83% of the U.S. fishery resources which have been assessed are classified as over- or fully utilized from a biological standpoint (USDOC, 1993b). Since most fisheries are still characterized by open-access, it seems fairly safe to suggest that the number of U.S. fisheries operating near the efficient point of effort, or harvesting using least-cost methods, is quite small (see Chapter 1 for definitions and graphical representation of maximum sustainable and maximum economic yield). While this statement is based on a highly oversimplified model, it perhaps offers some insight into the extent to which U.S. fisheries might be operating at excessive effort and harvest levels. Many would agree that what Higgs (1982) reported for the Washington salmon fishery holds for the majority of U.S. **fisheries:**

> "Today, from a comprehensive point of view, the Washington salmon fishery almost certainly makes a negative contribution to net national product. The opportunity costs of the socially unnecessary resources employed here, plus the socially unnecessary costs of governmental research, management, and regulation, are greater than the total value added by all the capital and labor employed in the fishery."

For U.S. fisheries to make positive net contributions to the economy they must operate closer to or at economically sustainable levels. This requires the establishment, implementation, and enforcement of management systems that eliminate the market failure of open-access in fisheries. In systems with catch rights, for example, fishermen own the right to annually harvest a known amount of the fish stock. Fishermen can buy from or sell rights to others, until they hold rights to harvest exactly as much fish as is profitable for them. The least profitable fishermen would probably sell their rights to fish and exit the fishery. The most profitable fishermen would remain in the fishery, using cost-effective methods to fish; society would be better off because the right amounts of capital, labor and other inputs would be used in the harvest. By owning the right to a known portion of the stock, the remaining fishermen can operate when and where they like; the need to "race to fish" is eliminated because their share of harvest is guaranteed. Harvest can be postponed until later in the season, when fish are bigger and prices higher, and can be spread more evenly throughout the season. The incentive to fish under poor or dangerous weather conditions is reduced.

Such systems can be costly to implement, at least initially, and require a strong enforcement presence. The catch of each fisherman must be monitored to ensure that he catches only the amount to which he owns the right. If he exceeds his quota, he reduces the amount of fish available for other fishermen; the "race to fish" is reintroduced if fishermen believe that the amount of fish they are entitled to is being taken illegally by others. Despite potentially high "start-up" costs associated with these systems, in the long run, their implementation is the only way to regain the resource rent dissipated by open access and to ensure that the optimal amount of capital is invested in fisheries. The benefits to society will outweigh the costs of implementation and enforcement in most cases.

Managing for economic sustainability does not affect only commercial fisheries. One of the biggest challenges currently facing fisheries managers is the allocation of limited fish stocks between commercial and recreational fishermen. Central to the allocation process and embodied in Federal laws and regulations are recognition of the net economic benefits to both user groups from use of the resource as well as the impact of each group on the resource. The MFCMA was designed, in part, to enhance the economic value that all Americans derive from their publicly owned fish stocks. The Act promotes efficiency in the utilization of management measures and requires management measures to minimize costs (Sections 301(a)(5) and 301(a)(7)). One of the primary objectives of the MFCMA is to optimize the use of fish for food and recreation to provide the greatest overall benefit to the Nation (Section 301(b)(6)). The greatest net economic benefits are achieved by allocating total allowable catch such that fish are available to those who put them to society's highest-valued use. In other words, additional units of a fish stock would be allocated to the user generating the greatest net economic benefit with those units, whether recreational, commercial, or other, until the marginal net economic benefits are equal for all user groups.

THE U.S. SEAFOOD PROCESSING SECTOR

The processing and wholesale sectors are an integral part of the seafood industry, transforming domestically harvested and imported fishery products and delivering them to the final consumers. The primary processing sector includes firms that purchase the raw product from harvesters or importers and transform it into a final product or deliver intermediate products to the final producers; the primary wholesaling sector refers to those firms involved in an initial phase of distribution of the product, delivering products to processors or secondary wholesalers. The secondary wholesaling sector covers those firms that distribute the final processed products to the retail sector.

As in the harvest sector, technological developments advanced the processing and distribution of seafood. Cold storage and freezing plants used to store excess harvests were established as early as 1892, and they proliferated throughout the 20th century. The first distant-water cold storage plant was built in Costa Rica in 1936, allowing vessels to offload fish far from domestic ports. The canning process developed in France in the early 1800's found a ready use by 1878 in Alaska salmon fisheries and by 1900 in California's tuna fishery. Efficient methods for filleting and packaging fish were introduced during the early 1920's and continued to advance; today the seafood processing and marketing sector is a multi-billion-dollar industry.

Using NMFS Annual Survey data[5], Figure 2-12 shows the total number of U.S. processing and wholesaling plants from 1984 to 1993, as well as the total volume and value processed. While the overall number of processing plants remained fairly constant from 1982 to 1988, and has since risen, Figure 2-13 reveals that the number of plants entering and exiting the industry each year is not inconsequential. The sharp rise in entrants during 1988-89 is due to the initiation of reporting by Alaska and California plants, and some entry and exit is due to recoding, as discussed in footnote 4. However, the figure suggests that this sector is quite dynamic.

The total annual employment in processing plants peaked in 1991, while total employment in wholesale plants peaked in 1989 (Fig. 2-14). The average number of employees per processing and wholesaling plant declined after reaching high levels in 1986-87 (Fig. 2-15). Volume and value of processed output per employee rose during 1988-93, as per plant volume remained essentially unchanged and per plant value declined (Fig. 2-16). This could be due to technological advances that reduce reliance on labor, as well as exit of larger firms from the industry.

The processing sector is dependent on the harvest sector, and is subject to the seasonal variation inherent in most fisheries. Many firms compensate by diversifying, processing more than one species or product, but may still cease production for parts of the year. Others just operate seasonally. A potential benefit of management plans that smooth harvesting patterns, such as controlled access systems, would be the added scope for processing firms to smooth their production and delivery of fresh, high quality products. Estimation of the impacts on processors requires data not currently available. (Table 2-2 provides a list of data needs and analyses.) Economic losses in value due to lower fish quality may be substantial (Wilen and Homans[6]). In fisheries with a catch quota or in simple limited entry fisheries, fishermen race to harvest fish before the quota is filled, often forsaking quality for quantity. For example, historically a high percentage of the U.S. Pacific halibut catch has been landed without being gut-

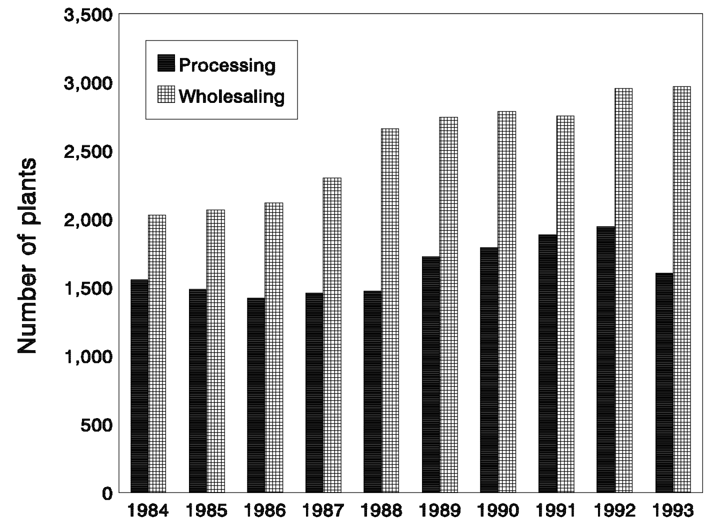


Figure 2-12
Number of U.S. processing and wholesaling plants.

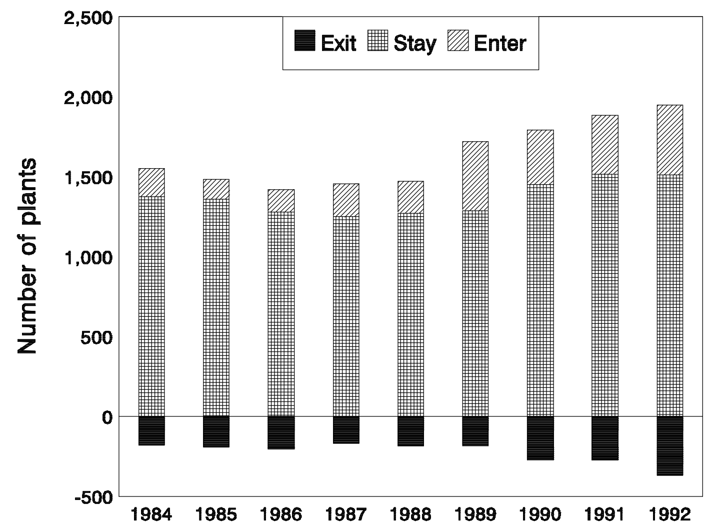


Figure 2-13
Number of U.S. processing plants entering, exiting, and staying in the industry.

[5]Some anomalies exist in the NMFS data. The NMFS definition of processing was changed in 1989 to include "dressed" product if the product was intended for export or was being delivered directly to final consumers. This category was previously excluded to eliminate the double counting that might arise when dressed product was delivered to another firm for further processing. Prior to 1989, Alaska processing plants were not surveyed by NMFS; the number of Alaska plants was estimated from state production records. California plants were not extensively surveyed prior to 1986. There are some inconsistencies in the recording of plant identification codes that make it difficult to track individual plants over time.

[6]Wilen, J. E., and F. R. Homans. 1993. Marketing losses in regulated open-access fisheries. Univ. Calif., Davis. Unpubl. manuscr., 8 p.

ted or iced, and processing has been delayed by landing gluts, both of which can reduce product quality. In the British Columbia halibut fishery, 42% of the halibut was marketed fresh prior to the implementation of individual vessel quotas (IVQ's) in 1991; since implementation, 94% has been marketed fresh. The average price per pound increased $0.68 after IVQ's were implemented. And notably, the 1993 price of Pacific halibut landed by U.S. fishermen is about $1/lb less than that landed by Canadian fishermen (Casey et al, 1995).

While thus far overcapitalization has been discussed in terms of the harvest sector, overcapitalization can also take place on land. In some fisheries, a large percentage of harvested fish needs further processing (as opposed to being primarily delivered fresh to markets) or a substantial volume of fish is harvested in a short time period (due, for example, to restricted harvest seasons or to catch quotas). In both cases, the high product volume gives firms an incentive to build larger, more capital-intensive processing plants than are necessary for much of the year. This, in turn, increases the cost of building a plant, which keeps potential competitors out through high entry costs, sometimes limiting the number of firms to just a few. As discussed in the "Primer" chapter, a market where there are a few buyers (processors) and many sellers (fishermen) is an oligopsony. In an oligopsony, the buyers can often influence, and will generally reduce, the price paid to sellers for their product. The producer surplus of fishermen is reduced when the processing sector is oligopsonistic.

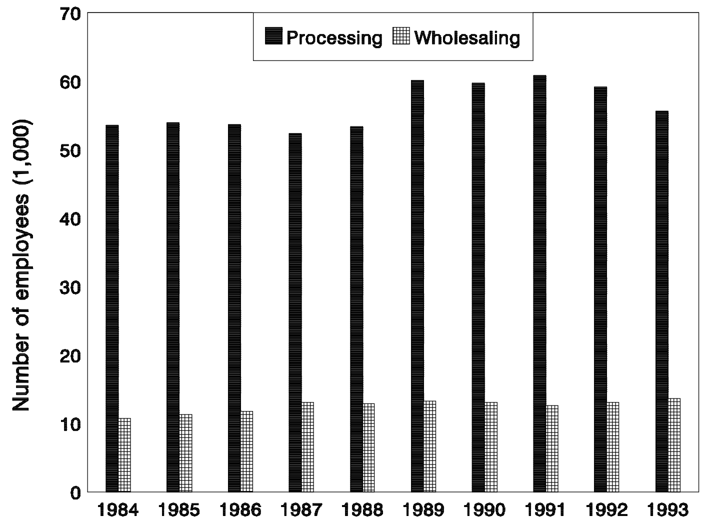


Figure 2-14
Number of employees in U.S. processing and wholesaling plants.

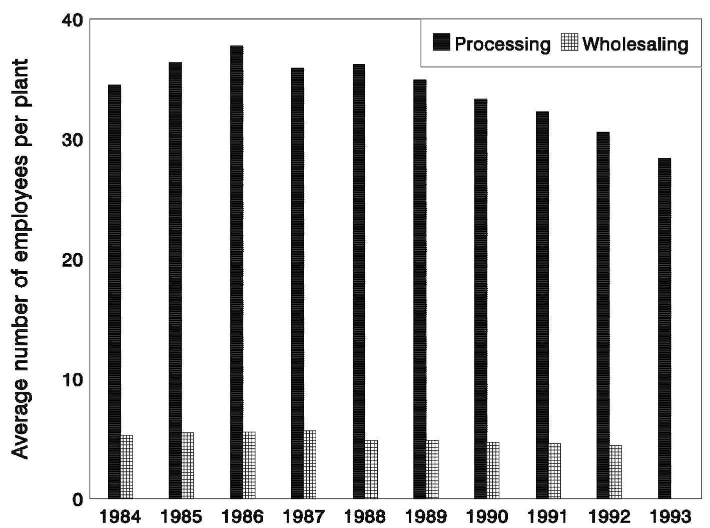


Figure 2-15
Average number of employees per processing and wholesaling plant.

Processing and Wholesale Sector Data

Data on the processing sector are available from a few sources. NMFS conducts an Annual Survey of Processors that contains information on the annual volume and value of processed product by processing plant, as well as annual and seasonal employment by both processing and wholesaling plants. Provision of these data are voluntary; however, approximately 95% of all processing and wholesaling firms are believed to be represented in the data set. The Food and Drug Administration (FDA) also surveys processing plants, but uses a different definition of processing; hence, there is some discrepancy between the number of firms included in the NMFS and FDA surveys. Specifically, the FDA counts a firm as a seafood processor if it makes any changes to the product, including the "dressing" of seafood. As such, the FDA survey includes supermarket chains and cottage industries not captured in the NMFS survey. Some information on processed seafood products can also be gleaned from the Bureau of Census, which maintains aggregate industry information based on the Standard Industrial Classification system.

The U.S. Seafood Trade Sector

The United States plays a major role in the international seafood market, importing and exporting billions of dollars worth of seafood each year. The United States is the world's primary exporter of seafood products in terms of value, and is the second largest importer (USDOC, 1994), trailing only Japan (Fig. 2-17 and 2-18). Developing country harvests have increased at a much higher rate in the last twenty years than in developed countries (FAO, 1993). As a consequence, all ten of the leading seafood importers are developed countries, while four of the leading seafood exporters are developing countries. Japan is clearly the primary consumer of U.S. fishery products (Fig. 2-19). In 1993,62% by value (58% by volume) of all U.S. edible seafood products, valued at $2 billion, were exported to Japan. This was almost five times as much as was sold to Canada, the next most significant importer of U.S. product.

Exports

The U.S. seafood trade market in part reflects conditions in its domestic fisheries. The real value of U.S. exports reached a record of almost $6 billion in 1992 (Fig. 2-20). The large jump between 1988 and 1989 reflects the elimination of joint ventures in Federal waters in 1989, which effectively ended foreign directed fishing in the U.S. EEZ. Concurrently, an international market developed for pollock roe and low unit-value, high-volume surimi supplied by U.S. processors. Salmon, crabs, caviar roe, and surimi comprised the United States' four most valuable export products in 1993, contributing approximately 61% of the total value but only 49% of the total volume of seafood products exported.

Three of the top ten exports are high-valued, low-volume shellfish products (crabs and crabmeat, shrimp, and lobsters), with relatively high prices per pound. The other seven products are finfish or finfish-related products. Salmon is by far the most valuable export product, comprising almost 25% of the total value of exports, even though salmon prices have declined over time due to a series of record or high harvests and because of the world-wide growth in salmon culture. The remaining finfish export products, with the exception of caviar and roe, can be characterized as

Table 2-2
Data needs and economic information for processing/wholesale sector.

Item	Coverage of data/estimates: Complete	Partial	By special study
Revenues and volume of processed product, by firm	✔		
Variable costs (including wages) and fixed costs of production, by firm			✔
Number and size of plants and/or processing vessels, by fishery or product		✔	
Number of full- and part-time employees by firm	✔		
Economic values (i.e., producer surplus and profits) by product			✔
Utilization rates, by firm			✔

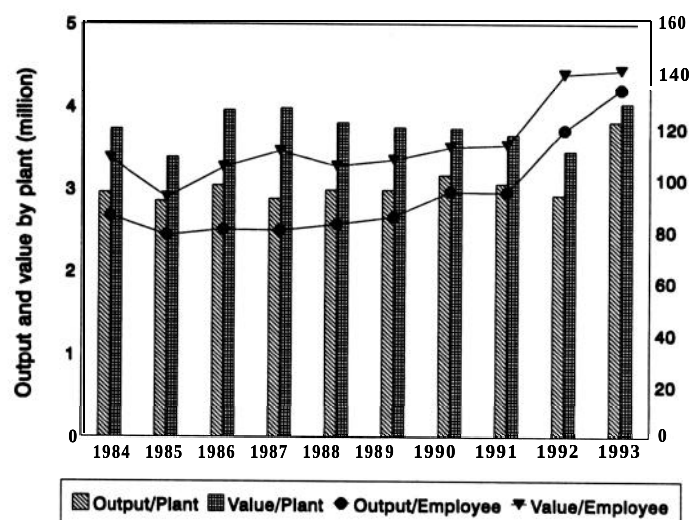
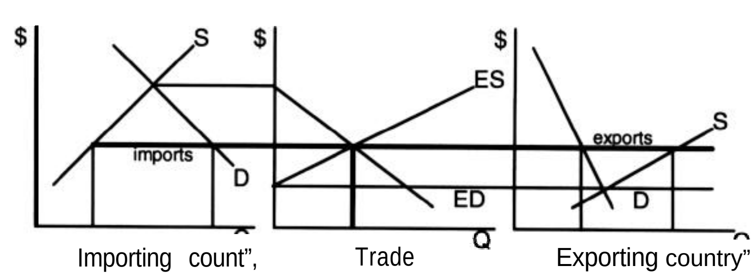


Figure 2-16
Average volume and real value of processed product by plant and by employee.



Excess demand, ED, [or excess supply, ES], is generated from prices higher [lower] than the equilibrium price in the importing [exporting] country. Trade occurs at a price somewhere between the prices in the two trading countries (equal price save for transportation/transaction costs).

high volume but low unit-value. Of the top ten products exported, seven originate predominantly in the Pacific Northwest and Alaska, consistent with the dominance of those fisheries at the harvest level.

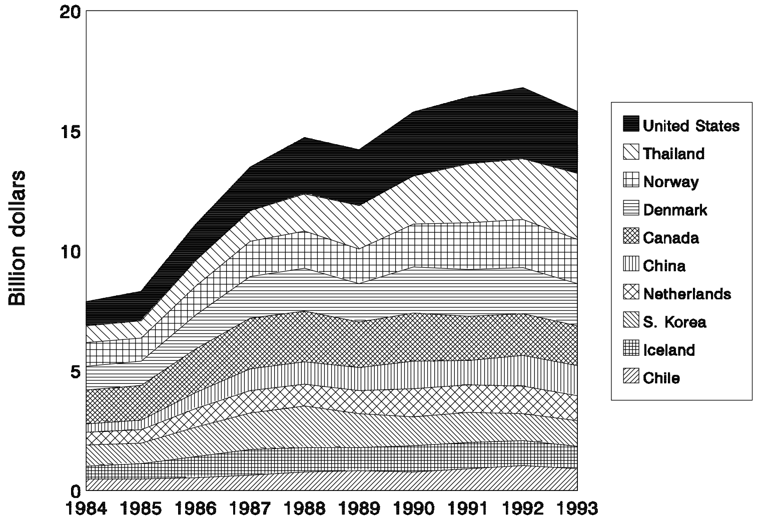


Figure 2-17
Real value of exports by leading exporting countries, for seven fishery commodity groups.

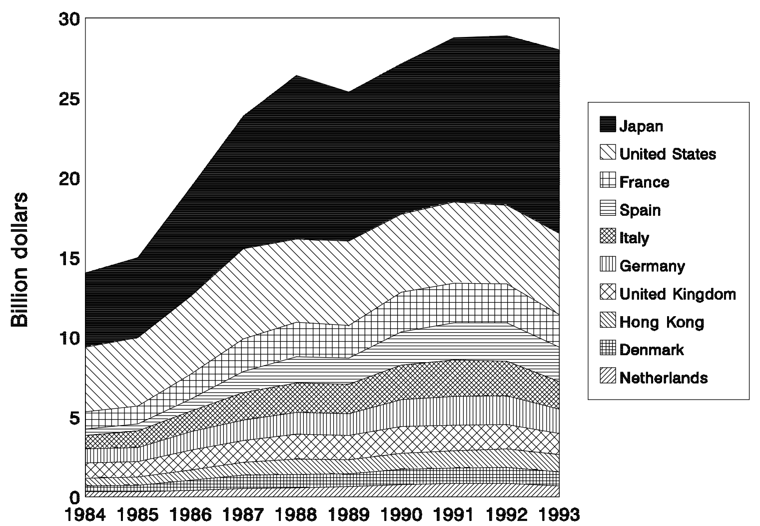


Figure 2-18
Real value of imports by leading importing countries, for seven fishery commodity groups.

Imports

Four of the ten most valuable edible seafood products imported by the United States in 1993 are high-valued shellfish (shrimp, lobsters, scallops, and crabs); domestic harvests of those species has either fallen or remained steady in recent years. Shrimp was by far the most valuable imported product in 1993; at $2.2 billion dollars, the value of shrimp was almost four times as high as that of tuna, the second highest-valued import. Shrimp has become such an important commodity that the Minneapolis Grain Exchange established a futures market for shrimp in 1993.

Trade and Efficiency

Economic efficiency in trade relies on the concept of comparative advantage: under free markets, a country produces goods for which it has lower relative costs of production and then trades with other countries to obtain those other goods that are produced more cheaply elsewhere. Common barriers to trade are quotas and tariffs, which are intended to provide an advantage to domestically produced goods by raising the price of imported goods. The consequence is generally a lower volume of trade and higher prices to consumers and domestic producers than would be obtained otherwise; resources are misallocated, and incomes and consumer surplus are reduced. Table 2-3 provides the status of data needs and analyses necessary to evaluate the costs and benefits of trade policies on the economy.

Trade in seafood can be hampered by the use of “nontariff” trade barriers, also intended to protect domestic interests, including human health. Nontariff trade barriers include the enforcement of minimum quality standards (e.g. in concentration levels of certain metals or in the methods of handling seafood), imposition of import quotas, requirement of “import licenses,” or restrictions on the method of harvest or production. Environmental interests are often enmeshed in trade issues as well and can provide effective barriers to trade. Perhaps the most publicized example of this is the United States’ use of trade embargoes against Mexican-caught tuna due to the high incidence of dolphin bycatch by Mexican tuna vessels. In this case, the General Agreement on Tariffs and Trade (GATT, described below) ruled that the United States was imposing unfair trade conditions on

Mexican yellowfin tuna products by requiring that the byproducts from tuna production be the same in both countries. (The West coast regional spotlight article describes the dolphin-safe policy imposed on U.S. tuna fishermen.) A similar conflict exists in the Mexican and U.S. shrimp fisheries; U.S. fishermen are now required to use Turtle Excluding Devices (TED's) that allow sea turtles to escape shrimp nets and thereby avoid drowning, while the Mexican shrimp fleet is currently required only to show progress towards implementation of TED's.

Free Trade Agreements

Efforts to reduce barriers to trade are addressed by GATT and the North American Free Trade Agreement (NAFTA), both implemented in 1994. NAFTA is intended to reduce or eliminate trade barriers between Canada, Mexico, and the United States, while the GATT is a multinational agreement. Canada and Mexico are relatively substantial seafood trading partners with the United States. Pre-NAFTA tariffs on seafood exported to Mexico from the United States were between 0 and 20% while most seafood products imported from Mexico and Canada faced no tariffs. Under NAFTA, tariffs are either eliminated immediately or are scheduled to be phased out completely within 15 years. In addition, provisions are made to ensure that minimum quality standards cannot be used to preclude trade, while ensuring that existing health and safety standards are not jeopardized.

A 1993 Department of Commerce report states that seafood is one of the "best sales prospects" in Mexico (USDOC, 1993a). The opening of shipping lines (railroad and highway) between Mexico and the United States will allow faster and more efficient delivery of fresh and frozen seafood between the two countries. The reduction of existing trade barriers will make U.S.-produced seafood more competitive in Mexican markets, and it should ultimately increase the supply of seafood exported to Mexico. As Mexican incomes and population continue to rise, the demand for seafood, particularly processed U.S. seafoods, is expected to rise. Consequently, for those fisheries with rational fisheries management programs in place, the producer surplus of U.S. harvesters and processors should increase.

Retail Demand for Seafood

The ultimate destination of harvested and processed fish is the seafood consumer. Consumer demand essentially drives the fishing industry; consumers' preferences and their willingness to pay for fish are major determinants of which species are caught and sold in the marketplace. Socioeconomic forces in the United States over time have undoubtedly influenced the current

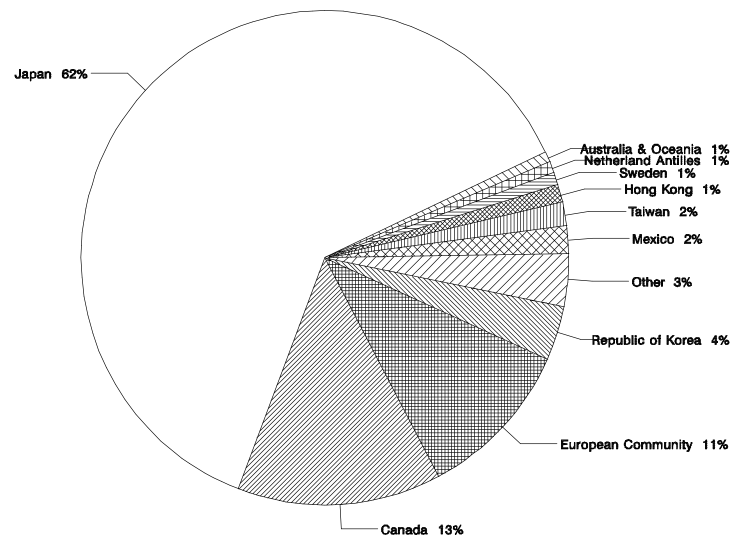


Figure 2-19
Top ten countries of destination for U.S. seafood exports in 1993, by percentage of value. (Total value of edible exports = $3.1 billion.)

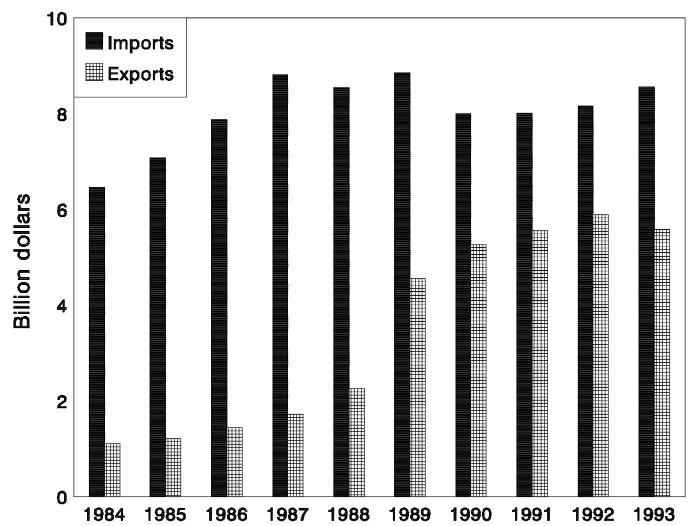


Figure 2-20
Real value of imports and exports (edible and nonedible products).

Table 2-3
Data needs and economic information for trade sector.

Item	Coverage of data/estimates: Complete	Partial	By special study
Volume and value of imports, by fishery product and country of origin	✔		
Volume and value of exports, by fishery product and country of destination	✔		
Identification of tariff and nontariff trade barriers		✔	
Economic value of losses (i.e., lost consumer and producer surplus) attributable to trade barriers			✔

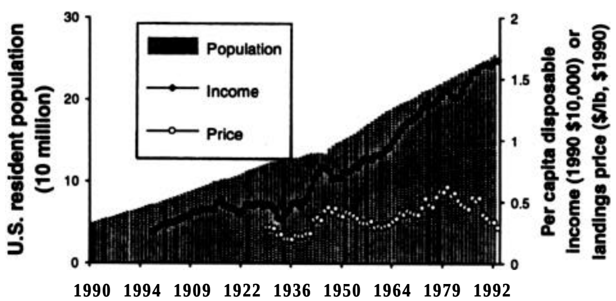


Figure 2-21
Socioemnomic trends.

makeup of the seafood industry. Population, real per capita income and ex-vessel prices are three factors that economic theory suggests should explain the aggregate demand for seafood. The U.S. population has grown at a rate of about 1% per year over the past 40 years (Fig. 2-2 1). More consumers translates to more total seafood demanded. Economic theory also predicts that the quantity demanded of a "good" increases as income rises. Real per capita income in the United States has increased every year and will likely continue to do so, indicating that per capita consumption of seafood should also continue to rise.

The early 1980's ushered in an era of increased public awareness of the health benefits associated with consuming seafood, these benefits were widely publicized by the industry and the media and were even promoted by the Federal government. As consumers became aware of these health benefits, their preferences may have shifted away from beef and chicken towards seafood, resulting in greater seafood consumption than would otherwise have occurred. That is, it is possible that preferences for seafood have been changing over time (i.e. the demand curve for seafood may have shifted upward). Changes in technology in the harvest and processing sectors over time increased the availability of fresh and frozen seafood to consumers, also possibly serving to shift the demand for seafood by making it more palatable as well as accessible. It is apparent that both demographic and socioeconomic changes in the United States may continue to contribute to further increases in seafood consumption. This provides fishermen with incentives to search for new ways to increase supply.

An understanding of the responsiveness of consumers to changes in prices (price elasticity) and quality, their willingness to substitute among various seafood products and other protein sources, and their readiness to purchase imported products is critical for a number of reasons:

1) Regulations imposed on U.S. fisheries affect the quantity of seafood harvested and the price paid for it. Consumer responsiveness to price changes plays a large role in determining the impact of a regulation on fishermen. If consumers can substitute one fishery product for another fairly easily, demand is more likely to be price elastic; when the price of one fish product increases, consumers will purchase a different product if they perceive that product to be a close substitute for the original one. If demand for a particular product is relatively price elastic then a regulation that restricts supply will reduce producer surplus more than if demand were price inelastic. Thus, understanding consumer demand for seafood can help assess whether proposed regulations will have the intended effect on commercial fishermen.

2) A full accounting of the impacts of a regulation, to assess the net economic benefits, includes the changes in consumer surplus as well as producer surplus. Models of consumer behavior to estimate the demand curve for seafood products are critical for obtaining reliable estimates of consumer surplus and hence, total net economic benefits.

3) A basic understanding of consumer demand for seafood is necessary for predicting how consumers react to both positive and negative information. For example, as the seafood safety issue becomes increasingly important, models of retail demand for seafood could assist government regulators and the industry in understanding how con-

sumers respond to perceived and actual risks, and how they might be influenced in the marketplace. From a public policy standpoint, this is especially important for determining how best to minimize consumer risk from seafood consumption and for determining potential losses in consumer surplus due to contaminated seafood (e.g. from oil spills or outbreaks of diseases in harvest areas). From an industry standpoint, models of retail demand yield information on which advertising strategies might be most effective in inducing consumers to purchase more seafood (or to convince new consumers to try seafood). For example, local supermarket advertising of price reductions might be more effective at stimulating demand than generic advertising of all seafood by the industry.

4) Demand studies can reveal seasonal variations and identify critical substitute products, information useful in determining the impact on consumers of a regulation imposed on a particular species or fishery, or the impact of a seasonal closure of a fishery.

While few data currently exist on the retail demand for seafood (Table 2-4), aggregate measures yield some information on gross trends. Per-capita consumption of all seafood rose steadily from 1983 to a peak in 1987 at 16.2 pounds per person (Fig. 2-22). Since then, there have been slight decreases in per-capita consumption of all seafood, but consumption of fresh and frozen seafood has been increasing since 1990, to 10.2 pounds per person in 1993. During the same time period, seafood prices, as measured by the consumer price index for fish, have climbed steadily, remaining above the average price of both poultry and meat since 1985 (Fig. 2-23). This suggests that the "average" consumer is purchasing increasingly more seafood despite higher prices, and it may indicate that the demand for seafood has increased over time.

American consumers are eating more and more meals away from home; expenditures on food eaten away from home have increased at about 2% per year since 1983 (USDA, 1993). According to a nationwide pilot study of seafood consumption performed in 1993 for NMFS, 44% of shellfish consumption and 29% of finfish consumption occurs in restaurants or establishments outside the home (NFI, 1994). Thus, if the trend toward eating out continues, seafood consumption will also likely increase.

The benefits of achieving economic sustainability of fisheries would extend to the retail sector. For example, a consistent supply of fish is cited as the biggest problem with "sourcing," or obtaining, seafood in a 1994 survey of more than 13,000 restaurants (Anonymous, 1994). While aquacultural products, typically produced with less seasonal

Seafood Safety

Seafood safety is an important issue facing the processing sector. Seafood processing is unique among food services because a wide range of species and products are handled, each with its own contamination and spoilage risks. Fish and shellfish contamination can arise from: bacteria and viruses from harvest waters, naturally occurring marine toxins; chemicals and elements in the water (i.e. mercury, lead, cadmium, PCB's, dioxins, and pesticides), and improper handling. In addition, establishment and enforcement of seafood safety standards are complicated by the wide variety of harvesting, handling, and processing methods.

Seafood processing quality is jointly overseen by the FDA, the Environmental Protection Agency (EPA), and NMFS. Regulation relies on mandatory, but periodic, inspections of seafood plants (by FDA) and on voluntary inspection and certification services (by NMFS). Infrequent visual inspection is inadequate for seafood because most contamination common to seafood cannot be detected this way. Therefore, the FDA and NMFS have proposed new methods for regulating the processing and wholesaling of seafood, collectively called HACCP, for Hazard Analysis of Critical Control Points. HACCP is a risk assessment system that identifies and regulates critical points of the production process prone to contamination or spoilage. Under this program, domestic processors, distributors (packers, repackers, wholesalers, and warehouses), importers (and therefore foreign processors shipping to the United States), and at-sea processors are required to develop and implement HACCP plans.

The impacts of HACCP on the industry are as yet unclear. However, the FDA has identified and quantified some of the expected benefits and costs of using HACCP principles. Some of the benefits are: 1) reduced seafood-related illnesses, 2) decreased consumer anxiety, 3) increased nutritional benefits from increased consumption, and 4) reduction in resources used to combat negative perceptions of seafood. The value of experiencing fewer illnesses as a result of a better seafood supply is estimated to be between $15 and $75 million; the value of fewer deaths as a result of positive health benefits associated with consuming more seafood (e.g., less cardiovascular disease) is estimated to be $3 to $14 billion.

The costs of compliance identified by the FDA include: 1) the cost of retrofitting equipment, 2) cost of corrective actions when problems are identified, 3) personnel training costs, 4) monitoring costs associated with ensuring desired safety levels are achieved, 5) the purchase of new equipment such as temperature indicators and recorders, 6) the initial cost of creating a HACCP plan; and (7) the ongoing cost of recordkeeping. The FDA projects that implementation of HACCP will cost the average plant $24,000 in the first year, and $15,000 each succeeding year. In the aggregate, FDA estimates a total cost of $103 million in the first year and $65 million per year in the following years. These costs do not include those of domestic repackers and warehouses or to foreign processors.

Table 2-4
Data needs and economic information for retail sector.

Item	Coverage of data/estimates: Complete	Partial	By special study
Quantity purchased, and unit price paid, for seafood products and substitute goods			✔
Socioeconomic characteristics of consumers			✔
Estimation of demand curves and consumer surplus, by seafood product or fishery			✔

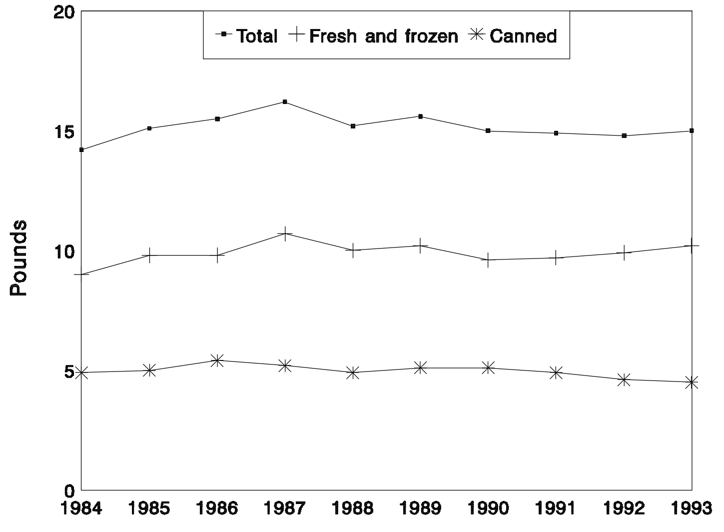
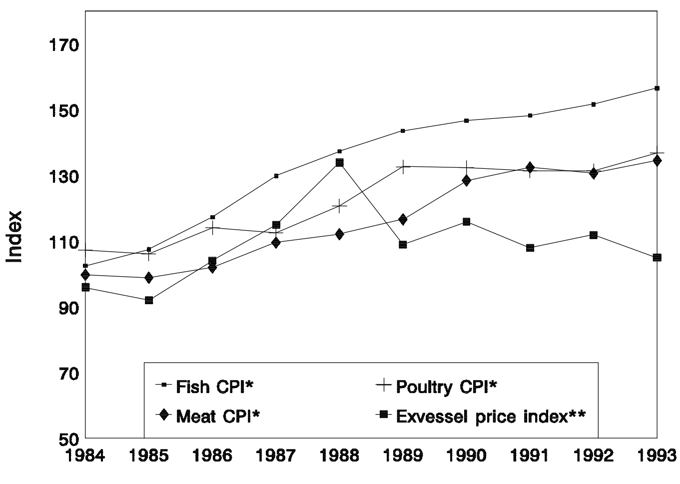


Figure 2-22
Per capita consumption of fish and shellfish.



*Bureau of Labor Statistics, **Fisheries of the United States
1982-84=100

Figure 2-23
Consumer price index (CPI) for fish, poultry, and meats.

variation than open-access fisheries, may help ease this problem, fisheries regulations that result in an increased, steady and predictable supply of fresh product will assist the industry.

The U.S. Recreational Harvest Sector

Fishing is considered recreational when pleasure, amusement, relaxation, and/or home consumption or subsistence are the primary motivations (USDOC, 1994). Marine recreational fishing is defined by NMFS as "any fishing in marine waters that does not result in the sale or barter of all or part of the fish harvested".[7] In contrast, commercial fishermen generally harvest for pay. By definition, the recreational and commercial fishing sectors are considered mutually exclusive user groups. However, the recreational and commercial fishing sectors are interdependent and have much in common: 1) both groups depend upon a renewable fishery resource and thus benefit from a healthy ecosystem, 2) both groups often fish for the same species, and 3) services like ice, repairs, equipment sales, and dockside facilities support both the commercial and recreational fishing sectors (Radonski et al., 1986). Thus, policies aimed at regulating one group almost always impact the other and often affect other sectors of the marine fishing industry.

Assessing the net economic benefits from various allocation scenarios requires the estimation of anglers' consumer surplus (ACS), commercial fishermen's producer surplus, and, theoretically, the consumer surplus for commercial catch as well. Estimation of the consumer surplus of recreational fishermen is not simple, nor are the appropriate data typically available. However, advances in recreational demand modeling have been made in the past decade, and estimates of the value of several components of the recreational fishing experience are available for some fisheries. For example, recreational demand models have been used to estimate the value of access to recreational fishing, the value of individual trips, and the effect of water quality and catch rate changes on the value of recreational fishing. These models can be used to estimate the impact on anglers of a seasonal closure, the implementation of or a change in bag limits, or a minimum size limit on fish kept.

[7]Adopted by NMFS in February 1993.

Various techniques have been developed to estimate ACS, and fishery managers are recognizing that these estimates provide valuable information. Importantly, managers are acknowledging that expenditures on recreational fishing do not measure the value of the recreational fishing experience to anglers (Chapter 1 discusses the difference between economic impact analysis and cost-benefit analysis). As the issue of allocation of scarce fishery resources becomes increasingly important, better data and models will be needed to more accurately estimate the economic value of this important sector of the fishing industry (Table 2-5 describes the current status).

Toward this end, a comprehensive study of anglers from New York to Florida was recently conducted by the University of Maryland, NMFS, and the Environmental Protection Agency (EPA) (McConnell and Strand, 1994). Among other things, this study estimates the annual value of access to saltwater fishing in each of the coastal states, the value of 2-month access, and the value of improved catch rates to anglers. A main objective of the study was to compare two methodologies used in recreational demand analysis (i.e. contingent valuation (CV) and random utility models (RUM)) and to evaluate the impact of the models on estimates of the value of recreational fishing.

Estimates of anglers' aggregate "willingness to sell" their rights to fishing for one year (data were collected in 1988-89) ranged from $77 million in Georgia to over $1 billion in Florida using the CV method; the estimated value of annual access using the RUM method ranged from $12.3 million in Delaware to $888 million in Florida. The study also estimates anglers' willingness to sell their fishing rights for a 2-month period, a scenario which might occur if a fishing area was closed temporarily due, for example, to an oil spill. As would be expected, average willingness to sell values were lowest between November and February, and were highest in July and August; people need greater compensation to give up fishing when the weather and catch rates are more favorable.

To demonstrate the usefulness of these models to policy makers, estimates of the willingness to pay to avoid a summer flounder moratorium by state and by 2-month period were calculated. Anglers were found to be willing to pay as much as $5.7 million to avoid the moratorium in New Jersey during July and August. In comparison, commercial harvest revenues for summer flounder in New Jersey in July and August of 1988 were $644,200 (recall that revenues do not measure producer surplus; revenues less variable costs would yield a measure of PS). While the two values are not directly comparable (e.g. commercial revenues are an overestimate of PS and do not include measures of the consumer surplus gained from summer flounder consumption), it is clear that in some fisheries, the value of the recreational sector may approach or exceed that of the commercial sector. Overall, the study demonstrates that 1) robust estimates of the recreational value of marine fishing can be obtained using a number of methods and 2) the value of recreational fishing is often quite high.

Table 2-5
Data needs and economic information for recreational sector.

Item	Coverage of data/estimates: Complete	Partial	By special study
Number of anglers, by fishery		✔	
Travel costs and expenditures on recreational fishing trips			✔
Socioeconomic characteristics of anglers			✔
Economic value (i.e., consumer surplus), by fishery			✔

Conclusions

It is well established in fisheries economics literature that management systems that control access to fishery resources provide fishermen with the incentive to harvest in the least-cost manner. The key to effective fisheries management is to design and implement strategies that induce long-run optimal choices of capital, labor, and other inputs. Support for the changes necessary to achieve economically sustainable fisheries is embodied in NOAA's Strategic and Implementation Plans (USDOC, 1996), both of which include specific initiatives and activities critical for effective implementation and analysis of controlled access systems. Doing so will ensure that resource rents, dissipated under open-access, are captured, and benefits to the Nation are maximized.

Regardless of the management schemes chosen, fishery managers need to be able to determine the change in net economic benefits for each user group to allocate scarce resources or to evaluate the effect of various regulations on stakeholders. It is critical to evaluate the producer surplus of fishermen, wholesalers and processors, and the consumer surplus of recreational anglers and seafood consumers. Understanding the decision-making behavior of commercial and recreational fishermen is a key to understanding how regulations will affect them and the fish stocks. This requires systematic collection of the relevant economic and sociological data, an improved understanding of the relevant markets for seafood products (wholesale, processing and retail) as well as the linkages between these markets, development of useful indicators of economic health that can be tracked over time and fisheries, and further development and application of appropriate models. Better data and models would give NOAA the ability to estimate the costs and benefits of regulations on a variety of user groups. All these important pieces of information are critical for making defensible management decisions.

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